Adaptive Mobile Web Applications: A Quantitative Evaluation Approach

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Abstract. The rapidly growing market of mobile devices has set a need for applications being available at anytime, anywhere, and on any device. Although this evolution provides users an unprecedented freedom, developers are facing the challenges caused by mobile device fragmentation. Current application development solutions are insufficiently optimized for the high diversity of mobile platforms and hardware characteristics. In this paper, we propose a novel approach for the development of mobile applications. An adaptive application composition algorithm is introduced, capable of autonomously bypassing fragmentation related issues. This goal is achieved by introducing a quantitative evaluation strategy derived from the Logic Scoring of Preference (LSP) method.

1 Introduction

Mobile is a powerful mass medium, with a greater reach and faster growth than any other known media type [1]. The mobile evolution has resulted in a general need for applications and services being available at all times. However, only few technologies are currently capable of supporting the development and delivery of a single application to many types of devices. This barrier is a result of the heavily fragmented mobile landscape. In order to cover a sustainable share of the mobile market, applications need to be made adaptable to various combinations of hardware, operating systems, APIs, etc.

In response to this challenge, the use of the web as an application platform is gaining momentum. Device independent web technologies such as HTML, CSS and JavaScript offer application developers an unprecedented market reach. Nevertheless, even with the use of standardized web technology, efficiently managing mobile fragmentation remains an important research topic. As browser implementations still contain many variability points, true mobile convergence is not to be expected any time soon [5].

Within this context, the goal of our research is to create automated adaptability processes for the development and delivery of mobile web applications. We present an application composition algorithm as a means of supporting mobile applications to autonomously resolve fragmentation related issues. The proposed algorithm aims at offering a robust and future proof approach for the flexible composition of web applications based on the individual capabilities of the mobile device.

2 Capability-Driven Progressive Enhancement

Since the early days of web engineering, developers have tried to cope with the differences between browsers. Graceful degradation is a widespread design strategy that focuses on providing optimal support for the most advanced browsers. Less capable browsers are only considered during the last development phase. This approach often results in a poor stripped-down version. The graceful degradation methodology expects users to just upgrade their browser when the degraded version does not fit their needs. However, for most mobile devices upgrading the default browser is not an option.

Progressive enhancement (PE) reverses the graceful degradation approach and aims at maximizing accessibility over browsers with different capabilities [8]. PE tries to achieve this goal by forcing developers to take the less capable devices into account from the very start of the development process. First, a basic markup document is created, providing an optimal experience for devices with the lowest common denominator (LCD) of available capabilities. Incrementally, one or more layers of structural, presentational, and behavioral enhancements are added in function of the browser's specific capabilities.

The PE methodology can be used in a mobile context to tackle fragmentation related issues. However, when turning the theoretical approach into actual practice, a number of important challenges come into play. Today, the use of externally linked resources (e.g. CSS, or JavaScript files) is the most common practice for selecting appropriate enhancement layers. This limits the number of detectable variability points, as browsers will only check for coarse-grained styling and scripting support. Compared to desktop browsers, the mobile ecosystem contains far more combinations of browsers with graded CSS and JavaScript support. To provide optimized usability, PE should also reckon with the different interaction methods and hardware characteristics offered by mobile devices. As we will discuss in the following section, the creation of a viable mobile PE solution requires an application development approach that supports the use of more fine-grained enhancement layers.

3 Adaptive Application Composition Algorithm

As a means to address the wide variety of mobile characteristics, we introduce a quantitative evaluation algorithm derived from the Logic Scoring of Preference (LSP) method [3]. The algorithm is designed to support fine-grained progressive enhancement and is capable of suggesting a stack of layers that optimally fits the user's mobile device. LSP is a quantitative decision method, assisting decision makers in the evaluation, comparison, and selection of complex hardware and software systems. The method has shown its use in various domains, especially concerning situations with large and complex solution spaces.

To evaluate a set of candidate solutions, LSP starts by assessing n individual performance variables. These variables define the n properties that an ideal solution is expected to have. As the algorithm deals with complex decision problems, most candidate solutions will not perfectly match the preset criteria. Nevertheless, such candidates should not be rejected, as their overall evaluation might still lead to an acceptable solution. LSP addresses this issue by taking into account how well a candidate matches the different performance variables. For each variable i, a degree of suitability $E_i \in [0, 1]$ is calculated. In order to attain these scores, LSP requires a predefined mapping function for each performance variable [4].

After obtaining the elementary degrees of satisfaction, all individual matching scores are to be combined into one objective overall suitability score. This aggregated score is used to determine the best-matching candidate. LSP supports the definition of an aggregation network, expressing the specific conjunction or disjunction relationships between individual scores. The standard aggregator mechanism is based on the superposition of fundamental Generalized Conjunction Disjunction (GCD) [2]. GCDs enable the specification of aggregations in terms of 17 graded combinations of conjunction and disjunction and are frequently implemented by use of Weighted Power Means (WPM). This approach allows an evaluator to precisely couple the mutual importance of individual suitability degrees. The calculated aggregation network results in an objective overall suitability score E, which is a combination of one or more WPMs using the individual suitability degrees as input parameters. After calculating E for each of the candidates, conclusions regarding the best-matching solution can be drawn by selecting the candidate with the highest overall suitability score.

LSP has the ability to flexibly, yet objectively, evaluate systems under various circumstances. This quality can be used as a basis for the adaptive composition of mobile applications. We propose a modification of the LSP method that supports the adaptive composition of mobile web applications. In this case, all possible sets of progressive enhancement layers are considered candidate solutions. Each candidate is individually evaluated by matching it to the mobile device's capabilities (e.g. available interaction methods, web technology support, etc.). The stack of enhancement layers with the highest score is then selected and applied to the mobile web application.

Table 1. Boolean mobile mapping function. Only perfect matches are scored.

Interaction capability	Match
Touch	0 %
Stylus	100 %
Joystick	0 %
Click wheel	0 %

Table 2. Fuzzy mobile mapping function. Also grading less-than-perfect matches.

Interaction capability	Match
Touch	75 %
Stylus	100 %
Joystick	30 %
Click wheel	10 %

Incorporating the LSP method in a mobile context requires the definition of mobile-relevant mapping functions. The functions specify the similarity between performance variables and the actual device capabilities. To illustrate the concept, both Table 1 and 2 contain the implementation of a mapping function that compares the performance variable "stylus interaction" with a device's interaction method. The function in Table 1 uses Boolean logic, which implies that only a perfect match is scored. The one in Table 2, on the other hand, uses fuzzy logic [6]. The latter approach makes much better use of the available scoring interval by also grading the less-than-perfect matches. This example highlights the importance of developing carefully thought through mapping functions. Efforts in the usability area from groups such as the W3C Mobile Web Best Practices Working Group can be used to generate sets of mobile mapping functions [7].

4 Conclusion and Future Work

In this paper, we introduced an algorithm in support of developing and delivering adaptive mobile web applications. The proposed method can serve as a basis for developers to create and maintain a single version of their mobile application, without being limited by fragmentation related issues. Our adaptive application composition algorithm is based on a quantitative evaluation algorithm derived from the Logic Scoring of Preference method. The proposed approach enables the automated and fine-grained progressive enhancement of web applications. The process is entirely driven by the characteristics of the user's device, in order to provide an optimal user experience.

While the extensive evaluation of our approach has yet to be carried out, initial testing of prototype implementations showed promising results. Future work includes the validation of our proposed approach as well as the extension of our algorithm towards supporting real time application request handling.

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